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Artículos científicos

Estrategias para la seguridad hídrica ante los cambios de precipitación por efectos del cambio climático

Strategies for water security in the face of changes in precipitation due to climate change effects

Estratégias para a segurança da água em face das mudanças de precipitação devido aos efeitos das mudanças climáticas

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Resumen

El cambio climático afecta negativamente los patrones de precipitación con breves periodos de lluvia que impactan en los ecosistemas a través de la sequía y producción de alimentos, lo que obstaculiza el suministro de agua en áreas marginadas como Las Ánimas, donde la clave de supervivencia se basa en la agricultura. Existen modelos globales de circulación como los MPI ECHAM 5 y HadGEN1 y escenarios A2 y B2 que permiten visualizar periodos de lluvias pasados y futuros para anticipar los cambios y generar estrategias desde ámbitos locales. En tal sentido, esta investigación fue de tipo cuantitativa, longitudinal-retrospectiva, no experimental y explicativa, donde se encontraron datos de la precipitación de los años 2015, 2016 y 2017 —como los puntos más críticos 2015 y 2016—, así como las variaciones para los años 2030 y 2050, que indican que la precipitación aumentará, pero con periodos más cortos, lo cual afectará la agricultura y generara problemas de seguridad hídrica y alimentaria en zonas rurales, donde es necesario recurrir a mecanismos de resiliencia comunitaria anual con mejoras en la captación, conservación y manejo del agua.

Palabras clave: cambio climático, escenarios, estrategias, modelos, precipitación, seguridad alimentaria, seguridad hidrica, sequías.

Abstract

Climate change negatively affects precipitation patterns, with brief periods of rainfall impacting ecosystems through drought and food production, hindering water supply in marginalized areas such as Las Animas, where the key to survival is based on the Agriculture. There are global circulation models such as the MPI ECHAM 5 and HadGEN1 and scenarios A2 and B2 that allow visualizing past and future rainy periods to anticipate changes and be able to generate strategies from local areas.

This research was quantitative, longitudinal-retrospective, non-experimental and explanatory, where precipitation data for the years 2015, 2016 and 2017 were found, as the most critical points (2015 and 2016), as well as the variations for 2030 and 2050 that indicate that precipitation will increase but with shorter periods, which will affect agriculture and generate water and food security problems in rural areas, where it is necessary to resort to annual community resilience mechanisms with improvements in catchment, conservation and water management.

Keywords: climate change, scenarios, strategies, models, precipitation, food security, water security, droughts.

Resumo

A mudança climática Afeta negativamente os padrões de precipitação, com breves períodos de chuva impactando os ecossistemas por meio da seca e da produção de alimentos, dificultando o abastecimento de água em áreas marginalizadas como Las Animas, onde a chave para a sobrevivência está baseada na agricultura. Existem modelos sistemas de circulação global como MPI ECHAM 5 e HadGEN1 e cenários A2 e B2 que permitem visualizar períodos de chuvas passados e futuros para antecipar mudanças e poder gerar estratégias a partir das áreas locais.

Esta pesquisa foi quantitativa, longitudinal-retrospectiva, não experimental e explicativa, onde foram encontrados dados de precipitação para os anos de 2015, 2016 e 2017, como os pontos mais críticos (2015 e 2016), bem como as variações para 2030 e 2050 que indicam que a precipitação aumentará mas com períodos mais curtos, o que afetará a agricultura e gerará problemas de segurança hídrica e alimentar nas áreas rurais, onde é necessário recorrer a mecanismos anuais de resiliência da comunidade com melhorias na captação, conservação e gestão da água.

Palavras chave: mudanças climáticas, cenários, estratégias, modelos, precipitação, segurança alimentar, segurança hídrica, secas.

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Introduction

Regional climate models (ECHAM, MPI ECHAM-5, ECHAM5 / MPI-OM, HadGEN1 and GCM) have been used in numerous studies for different purposes, for example, climate change phenomenon, seasonal prediction, climate variability, reanalysis and circulation. of the wind in regional settings (Agal'tseva, Spectorman, White & Tanton, 2010; Demuzere, Werner, van Lipzig & Roeckner, 2009; Frierson et al., 2013; Moser, 2010; Seth, Rauscher, Camargo, Qian & Pal, 2007; Xin, Dai, Li, Rong & Zhang, 2019). However, most of these projections are made globally (Barnett & Adger, 2007; Hanjra & Qureshi, 2010; Vörösmarty et al., 2010), so it is necessary to visualize them in regional contexts, specifically in rural territories that base its economy (Kang, Park, Kim, Lee & Back, 2009) and survival in agriculture (Suastegui Cruz et al., 2017).

These models allow investigating past, present and possible future conditions related to the climatic scenario of the town of Las Ánimas (Demuzere et al., 2009), where the water balance is obtained by comparing rainfall and the amount of water used depending on of changes due to climatic conditions (Bussotti, Pollastrini, Holland & Brüggemann, 2015; Schubert et al., 2016; Weber, 2010) over time (one of the most important moments was the 19th century) (Gleckler, Durack, Stouffer, Johnson & Forest, 2016; Riser et al., 2016; Solomon, Manning, Marquis & Qin, 2007).

Climatic alterations have generated changes in rainfall patterns and temperatures between 1.8 ° C and 4.0 ° C (Alexander, 2016; Böhm et al., 2010) with short-term rainfall, which currently has led to drought problems (Hernández-Mansilla et al., 2016; Schubert et al., 2016), as well as difficulties in food production and water availability (Anderson et al., 2016; Zhang, Chen, Li, Ding & Fu., 2018) , which has caused water and food insecurity and social conflicts (Buhaug, 2010; De Amorim et al., 2018; Jiménez-Cisneros, 2015; Porporato and Heguiabehere, 2018).

Therefore, it was important to know the rainfall that occurred in 2015, 2016 and 2017, which meant losses in production for the town of Las Ánimas; Therefore, it is necessary to anticipate future scenarios (2030 and 2050) to contribute to the water security of rural areas with similar characteristics in order to search for community adaptation mechanisms that improve the conservation and management of water resources.

Materials and methods

The study was quantitative, longitudinal-retrospective, non-experimental and explanatory. The dependent variable was the amount of rainfall, while the independent variable was the years. As an object of study, the precipitations of 2015, 2016 and 2017 were used, and the analysis of the possible scenarios for the years 2030 and 2050 of the town of Las Ánimas, municipality of Tecoanapa Guerrero (Mexico), located at coordinates 99 19 ′ 07 ″ south longitude and 16 ° 58 ′ 22 ″ west latitude, at a height of 660 m s. n. m. The climate is warm subhumid (García, 1973) with an average temperature of 31 ° C, annual rainfall of 1200 mm and a total of 1527 inhabitants (National Institute of Geography and Information Statistics [Inegi], 2010).

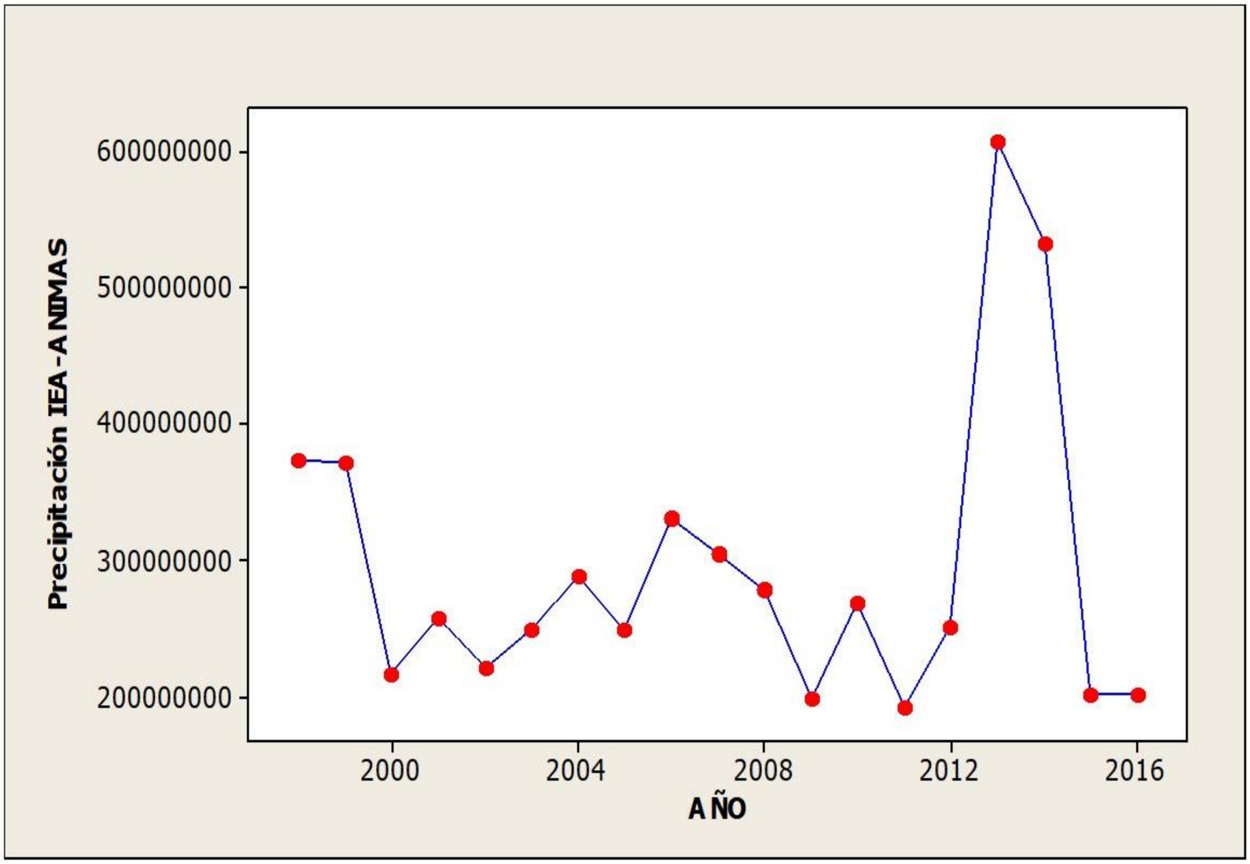
The data were collected from the digital climate atlas of Mexico and information was obtained from global circulation models (MPI ECHAM 5 and HadGEN1) and scenarios A2, B2 for the years 2030 and 2050; This type of models present information on the Mexican territory from which cuts were made to the national raster with the Las Ánimas shapefile, with the support of the ArcGIS 10.3 tool for monthly rainfall in the study area.

The information allowed creating databases of monthly precipitation for the years 2030 and 2050 in scenarios A2 and B2 with the Excel 2016 statistical package for the monthly water balance, with precipitation and consumption amounts obtained by Suastegui Cruz et al., (2018). The representation of the data was through histogram graphs for the water balance.

Results

As shown in figure 1, the annual water balance from 1998 to 2016 provides a history of the behavior of water scarcity in the study area. It is observed that the most critical years were 2000, 2002, 2009, 2011, 2015 and 2016, based on the activities carried out during the dry and dry period. The years prior to 2012 maintained a constant distribution between rainfall and water consumption, but it increased in 2013 when the tropical storms Ingrid and Manuel occurred in Guerrero (Toscana Aparicio and Villaseñor Franco, 2018). In 2014, the rains were accompanied by lower intensity tropical storms, while in 2015 and 2016 the rainfall was lower, causing problems of droughts in the dry period with losses in agriculture. (Suastegui Cruz *et al.*, 2018).

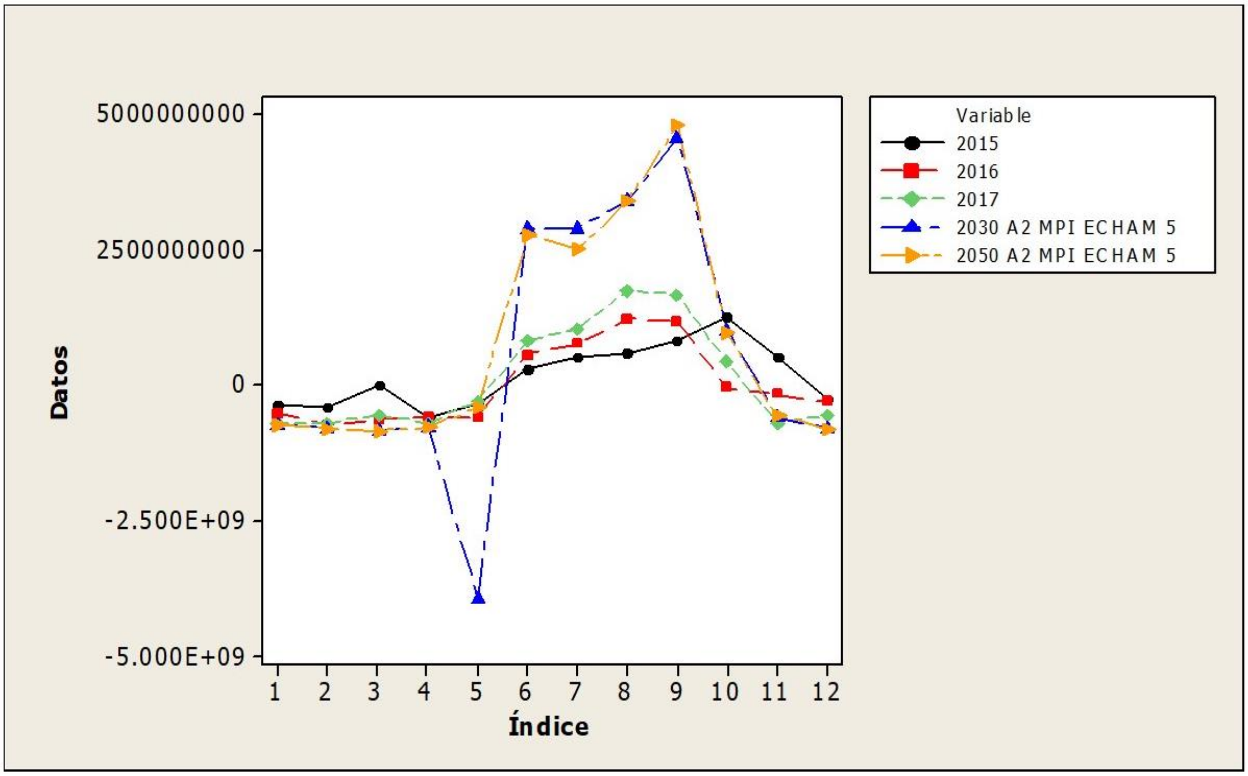
Figura 1. Balance hídrico anual de Las Animas Guerrero. para el periodo 1998-2016



Fuente: Elaboración propia

On the other hand, the projection of the monthly water balance for the A2 MPI ECHAM 5 model scenario (figure 2) for the year 2030 shows water shortages of approximately 4, 000, 000, 000 L / ha-1, but with prompt recovery in a period of 45 days. In the months of May and June, 2030 and 2050, the amount of water will increase, and the availability of water for the rest of the year will remain constant from June to September, in this sense and in a general way. This compared to the year 2017 that did not present water resource problems in the dry season.

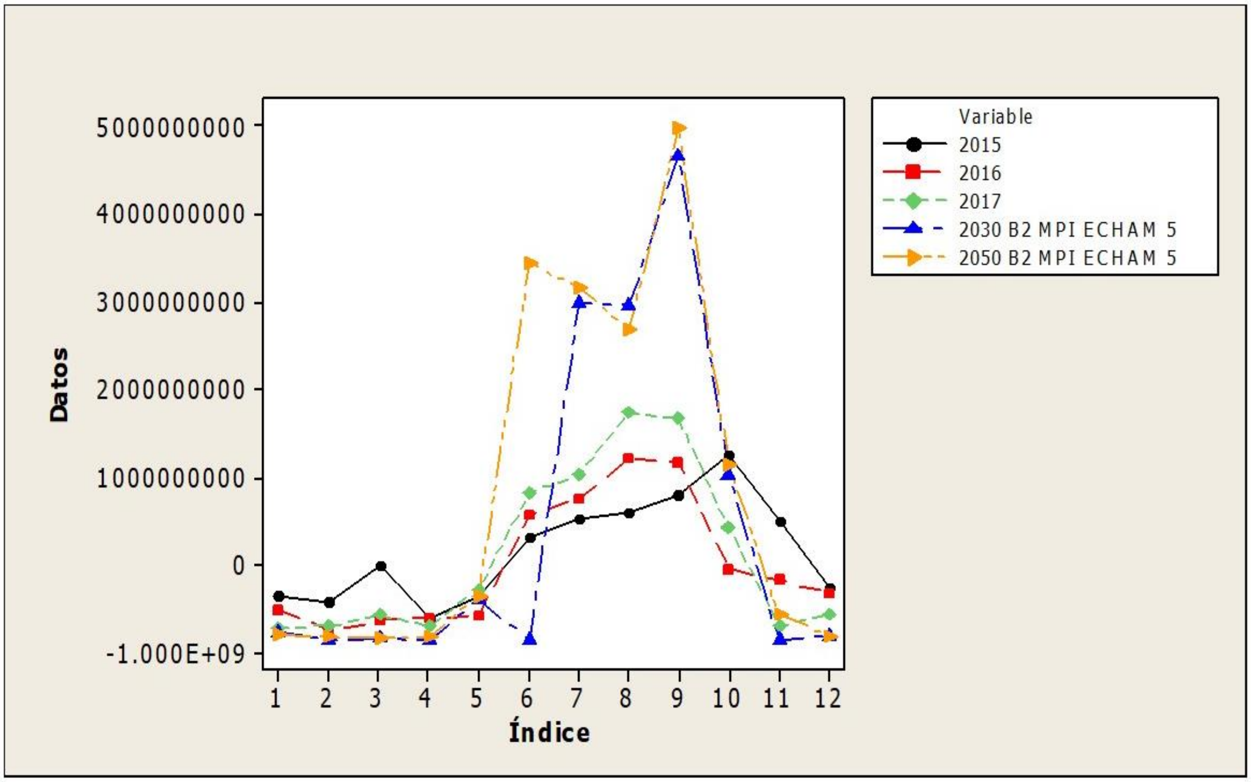
Figura 2. Distribución del balance hídrico mensual de los años 2015, 2016, 2017 y del modelo MPI ECHAM 5 del escenario A2 de los años 2030 y 2050 de Las Animas Guerrero



Fuente: Elaboración propia

Figure 3 shows the changes in precipitation for the year 2030, which will begin in June and the dry season will last from November-June with the longest duration in the locality; This is based on the projections of the B2 scenario, MPI ECHAM 5 model. As a result, in the year 2030 and 2050, precipitation will be more abundant in the month of September, which coincides with the A2 scenario.

Figura 3. Distribución del balance hídrico mensual de los años 2015, 2016, 2017 y del modelo MPI ECHAM 5 del escenario B2 de los años 2030 y 2050 de Las Animas Guerrero



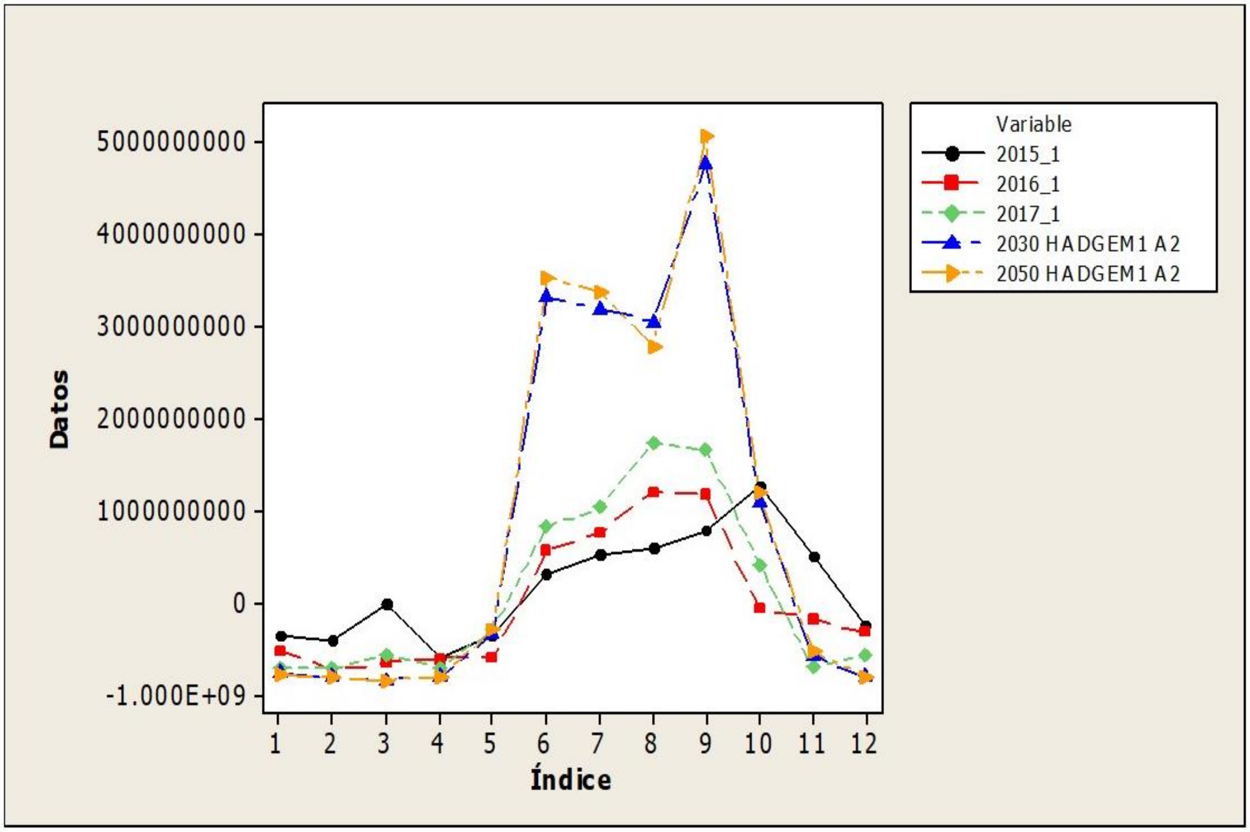
Fuente: Elaboración propia

In scenario A2, HadGEN1 model (figure 4), the rains are projected from July to October, where September will be the most abundant month with 4, 000, 000, 000 L / ha-1.

The data generated in this research show that existing water security will be affected by climate change and this type of projections will help to plan water strategies and adaptation processes to face the consequences.

In the case of Las Ánimas, there is no water security management plan, a situation that is also reflected in other parts of the Mexican territory.

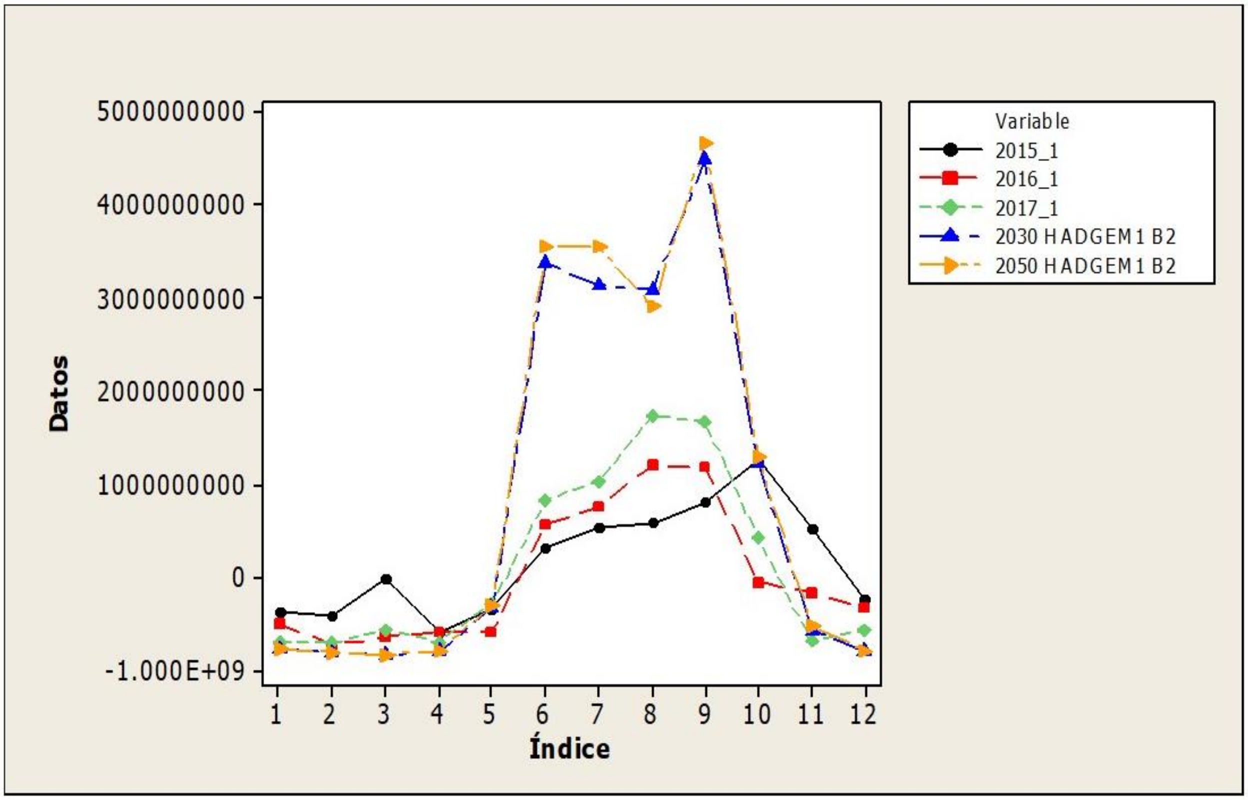
Figura 4. Distribución del balance hídrico mensual de los años 2015, 2016, 2017 y del modelo HADGEM1 del escenario A2 de los años 2030 y 2050 de Las Animas Guerrero



Fuente: Elaboración propia

With the circulation models, it can be seen that future rains will be similar to those of previous years (figure 5), although the difference lies in the short periods of rains. The predictions of these models allow us to visualize climate change as one of the main contributors to the adverse effects during droughts in agricultural areas.

Figura 5. Distribución del balance hídrico mensual de los años 2015, 2016, 2017 y del modelo HADGEM1 del escenario B2 de los años 2030 y 2050 de Las Animas Guerrero



Fuente: Elaboración propia

Discussion

The results show that in the water balance of the two models and scenarios A2 and B2 it will cause climate change to increase rainfall in less time with greater intensity (Wada & Bierkens, 2014; Werner et al., 2016).

Despite the excellent precipitation, the loss of organic matter will lead to the depletion of water resources during the dry season, which will reduce soil seepage and change, and use of local soil to recharge waterways, a similar situation that is presented in 2015 (Abou-Shaara, 2019; Merz, Parajka & Blöschl, 2011).

Changes in precipitation will be experienced in some regions of the world, with increasing variations and water scarcity (Kumar, Jain & Singh., 2010; Suastegui Cruz et al., 2018) in the study area, where the rainy seasons They began in the month of May, although there is currently an extension of the periods.

Climate change is expected to continue to affect regions and regional climatic conditions, resulting in erratic or irregular rains and droughts (Suryabhagavan, 2017).

The increase in rainfall will only occur due to phenomena such as El Niño and La Niña, as well as the situation presented in 2013 (figure 1) that caused losses in agriculture due to intense rains (McNeeley et al., 2018), this in contrast to Parry et al. (2007), who mention that food production in some regions of the world will be stable for the years 2030 and 2050, while Hasegawa et al. (2018) project an increase in water and food insecurity, with substantial increases in prices and hunger in the poorest regions, which will combine with heat waves during droughts and will cause damage to agriculture, extinction of species and shortages of water (Esparza, 2014; McMaster et al., 2019; Miralles, Gentine, Seneviratne & Teuling, 2019; Naumann et al., 2018; Sánchez-Balseca, Muñoz-Rodríguez and Aldás-Sandoval, 2019).

Today, water security is affected by climate change, which makes it difficult for countries that have not yet developed water strategies to cope with adaptation processes (Flörke, Schneider & McDonald, 2018; Sadoff and Muller, 2010).

For Sadoff and Muller (2010), water security can be achieved only by investing in the three “I's”: a) more accessible and adequate information, b) stronger and more flexible institutions, and c) natural and artificial infrastructure for storage, transport and water treatment for decision making. (p.5)

Conclusions

According to the A2 and B2 climate change scenarios for the years 2030 and 2050, based on the MPI ECHAM 5 and HadGEN1 models, in the territory that marks the community of Las Ánimas, municipality of Tecoanapa Guerrero (Mexico), will present higher annual rainfall for the years 2030 and 2050 compared to the years 2015, 2016 and 2017. In this sense, the same current use of water by the community is considered where the water balance will be higher, caused by the increase in rainfall in shorter periods and with extension in dry periods. Therefore, it is necessary to search for an annual community resilience mechanism with improvements in the collection, conservation and management of water to really contribute to local water and food security.

Future lines of research

This study can be a reference for future research related to environmental sciences or for those that orient their lines towards environmental problems such as climate change, water scarcity and food production. In this sense, it is worth noting that similar research has been carried out in Latin American countries, although few studies have been carried out in Mexico, so this would set the tone for understanding from the local point of view what will be the consequences that climate change will generate in rural localities that carry out activities. agricultural crops in the rainy season. When phenomena of water and food droughts usually occur, there will be economic and social effects. For this reason, it is suggested to guide lines of investigation of the perception of the inhabitants of rural areas about the consequences that low rainfall is generating in their environment.

Every year there is insecurity on the part of people about what will happen with the rainy season: if it will be a good year for production and if there will not be hurricanes or heavy rains. Inappropriate practices that affect the environment contribute to modifications for rainy periods. The result and understood analysis set the standard to suggest that the population promote the culture of risk prevention and the environment, with the rational use of their natural resources, that through their empirical knowledge they have a conscience for the care and preservation of its environment.

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